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# UNITED STATES PATENT APPLICATION TRANSMITTAL FORM

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**Washington, D.C. 20231**
**Attention: DO/EO/US**

Docket No.: 20 99 0025

Dear Sir:

Transmitted herewith for filing is the patent application of

| | |
|---|---|
| Applicant (s): | Rolf STEINER |
| For: | MINIMIZING WINDOWING EFFECTS IN PARTICULAR FOR SIGNAL RECOVERY |
| International Application No.: | PCT/EP99/10349 |
| International Filing Date: | 23.12.99 |

## ENTERING OF U.S. NATIONAL STAGE UNDER 35 U.S.C. §371

Transmitted herewith for filing are the following documents submitted under 37 C.F.R. §1.495(b) for the purpose of entering the national stage in the United States of America as an elected office. Enclosed are:

| | |
|---|---|
| ____ | Specification and Claims with Declaration; |
| XXX | Specification and Claims *without* Declaration; |
| XXX | 2 (two) sheets of drawings; |
| XXX | Preliminary Amendment; |
| ____ | An Assignment of the invention to: _____including $40.00 recordation fee; |
| ____ | The certified copy of a priority application; |
| ____ | Information Disclosure Statement with copies of patent(s) (Form - PTO-1449); |
| ____ | The undersigned attorney has verified that the applicant is entitled to a Small Entity Status; |

XXX  Priority of PCT International Application No. PCT/EP99/10349 filed on 23 DECEMBER 1999 is claimed under 35 U.S.C. §119 and 35 U.S.C. §365;

____  Cover page of published PCT Publication No. __________;

____  Copy of International Preliminary Examination dated _____;

____  Copy of PCT Demand Under Article 31; and

XXX  Copy of International Search Report dated 29 AUGUST 2000.

XXX  Copy of Written Opinion.

____  Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)) are transmitted herewith.

The Filing Fee is calculated below.;

| CLAIMS AS FILED | | | | |
|---|---|---|---|---|
| (1) For | (2) Number Filed | (3) Number Extra | (4) Rate | (5) Basic Fee $710/$740//$890/ $1,040/$100 |
| Total Claims | 15– 20 = | 0 | x $18.00 | **$0** |
| Independent Claims | 5- 3 = | 3 | x $84.00 | **$252.00** |
| Multiple Dependent Claim Fee | | | | x $280.00 = $0.00 |
| **TOTAL FILING FEE** | | | | $1,142.00 |
| 1/2 FILING FEE FOR SMALL ENTITY | | | | $ |

XXX  Firm's check in the amount of $ **1,142.00** to cover the filing fee;

XXX  The Commissioner is hereby authorized to charge any additional fees under 37 C.F.R. 1.16 and 1.17 which may be required with this communication or during the entire pendency of the application, or credit any overpayment, to **Deposit Account No. 01-0467.** A duplicate copy of this Form is enclosed.

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January 16, 2002
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANT: Steiner, R.

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TITLE: MINIMIZING WINDOWING EFFECTS IN PARTICULAR FOR SIGNAL RECOVERY

Attorney Docket No.: 20 99 0025

Commissioner for Patents
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Allison Berkman
Name

Allison Berkman
Signature

## PRELIMINARY AMENDMENT

Dear Sir:

Please amend the application as follows:

In The Abstract

Please amend the abstract as follows:

A measured signal, such as a high-speed digital pulse, transmitted through a system is corrected. The measured signal is sampled to a sampled signal sequence, and a signal series is provided as a plurality of the sampled signal sequences put together successively. The signal series is windowed with a window function, and a corrected measured signal is recalculated from the windowed signal series using information about the frequency-dependency of the system.

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In The Claims

Please amend the claims as follows:

1. (Amended) A method for correcting a measured signal transmitted through a system, the method comprising:

sampling the measured signal to a sampled signal sequence,

providing a signal series as a plurality of the sampled signal sequences put together successively,

windowing the signal series with a window function, and

recalculating a corrected measured signal from the windowed signal series using information about the frequency-dependency of the system.

2. (Amended) The method of claim 1, wherein recalculating a corrected measured signal from the windowed signal further comprises:

transforming the windowed signal series from time domain into frequency domain,

modifying the transformed signal series with a transfer function as a function of frequency of the system, preferably by multiplying the transformed signal series with the inverse transfer function of the system,

re-transforming the modified transformed signal series back from the frequency domain into the time domain, and

receiving the corrected measured signal from the re-transformed signal series.

3. (Amended) The method of claim 1, wherein recalculating a corrected measured signal from the windowed signal further comprises modifying the corrected measured signal with a function inverse to the window function.

4. (Amended) The method of claim 2, wherein receiving the corrected measured signal from the re-transformed signal series further comprises

selecting a corrected signal sequence substantially corresponding to the sampled signal sequence.

6. (Amended) The method according to claim 1, wherein sampling the measured signal is executed by a measuring device at the highest accuracy provided by said measuring device.

7. (Amended) A method for correcting a measured signal transmitted through a system having a transfer function as a function of frequency, the method comprising:

sampling the measured signal to a sampled signal sequence,

providing a signal series as a plurality of the sampled signal sequences put together successively,

windowing the signal series with a window function,

transforming the windowed signal series from time domain into frequency domain,

modifying the transformed signal series with the transfer function of the system, preferably by multiplying the transformed signal series with the inverse transfer function of the system,

re-transforming the modified transformed signal series back from the frequency domain into the time domain, and

receiving a corrected measured signal from the re-transformed signal series.

8. (Amended) A method for providing a measured signal for further processing, the method comprising:

sampling the measured signal to a sampled signal sequence, and

providing a signal series as a plurality of the sampled signal sequences put together successively.

9. (Amended) A software program storable on a data carrier, for executing a method when operated in a computer system, said method comprising:

sampling the measured signal to a sampled signal sequence,

providing a signal series as a plurality of the sampled signal sequences put together successively,

windowing the signal series with a window function, and

recalculating a corrected measured signal from the windowed signal series using information about the frequency-dependency of the system.

10. (Amended) An apparatus for executing a method for correcting a measured signal, said apparatus comprising:

a measuring device for sampling the measured signal to a sampled signal sequence,

a signal multiplication unit for providing a signal series as a plurality of the sampled signal sequences put together successively,

a device for performing windowing functions for windowing the signal series with a window function, and

a recalculation unit for recalculating a corrected measured signal from the windowed signal series using information about the frequency-dependency of the system.

11. (Amended) An apparatus for correcting a measured signal transmitted through a system comprising:

means for sampling the measured signal to a sampled signal sequence,

means for providing a signal series as a plurality of the sampled signal sequences put together successively,

means for windowing the signal series with a window function, and

means for recalculating a corrected measured signal from the windowed signal series using information about the frequency-dependency of the system.

Please add the following new claims:

12. (Newly added) The method of claim 1, wherein said measured signal is a high speed digital pulse.

13. (Newly added) The method of claim 7, wherein said measured signal is a high speed digital pulse.

14. (Newly added) The method of claim 8, wherein said measured signal is a high speed digital pulse.

15. (Newly added) The apparatus of claim 11, wherein said measured signal is a high speed digital pulse.

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## Remarks

Claims 1-11 remain in the application and claims 12-15 have been newly added.

The Abstract of the Disclosure has been amended to eliminate reference numbers and to comply with MPEP 608.01(b).

Claims 1-4 and 6-11 have been amended to eliminate the term "preferably," to eliminate phrases and designations referring to claim elements as steps, and to eliminate multiple dependencies.

Newly added claims 12-15 have been added to expressly recite the features of claims 1, 7, 8, and 11 previously referred to as "preferable."

As such, claims 1-4 and 6-11 have been clarified by amendment for purposes of form. It is respectfully submitted that the amendments to claims 1-4 and 6-11 are neither narrowing nor made for substantial reasons related to patentability as defined by the Court of Appeals for the Federal Circuit (CAFC) in Festo Corporation v. Shoketsu Kinzoku Kogyo Kabushiki Co., Ltd., 95-1066 (Fed. Cir. 2000). Therefore, the amendments to claims 1-4 and 6-11 do not create prosecution history estoppel and, as such, the doctrine of equivalents is available for all of the elements of claims 1-4 and 6-11.

Consideration and allowance of the application is respectfully requested.

Attached hereto is a marked up version of the changes made to the specification and claims by the current amendment. The attached page is captioned "Version With Markings to Show Changes Made."

Respectfully submitted,

Paul D. Greeley

1-15-02
Date

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Attorney Docket No.: 20 99 0025

VERSION WITH MARKINGS TO SHOW CHANGES MADE

In The Abstract

Please amend the abstract as follows:

[Disclosed is the correcting of a] A measured signal [(40)], such as a high-speed digital pulse, transmitted through a system [(30)] is corrected. The measured signal [(40)] is sampled to a sampled signal sequence, and a signal series is provided as a plurality of the sampled signal sequences put together successively. The signal series is windowed with a window function, and a corrected measured signal is recalculated from the windowed signal series using information about the frequency-dependency of the system.

[[Fig. 3]]

In The Claims

Please amend the claims as follows:

1. (Amended) A method for correcting a measured signal[, preferably a high-speed digital pulse,] transmitted through a system, the method comprising [the steps of]:

[(a)] sampling the measured signal to a sampled signal sequence,

[(b)] providing a signal series as a plurality of the sampled signal sequences put together successively,

[(c)] windowing the signal series with a window function, and

[(d)] recalculating a corrected measured signal from the windowed signal series using information about the frequency-dependency of the system.

2. (Amended) The method of claim 1, wherein [step (d) comprises the steps of] recalculating a corrected measured signal from the windowed signal further comprises:

[(d1)] transforming the windowed signal series from time domain into frequency domain,

[(d2)] modifying the transformed signal series with a transfer function as a function of frequency of the system, preferably by multiplying the transformed signal series with the inverse transfer function of the system,

[(d3)] re-transforming the modified transformed signal series back from the frequency domain into the time domain, and

[(d4)] receiving the corrected measured signal from the re-transformed signal series.

3. (Amended) The method of claim 1 [or 2], wherein [step (d)] recalculating a corrected measured signal from the windowed signal further comprises [a step of] modifying the corrected measured signal with a function inverse to the window function.

4. (Amended) The method of claim 2 [or 3], wherein [the step (d4) comprises a step of] receiving the corrected measured signal from the re-transformed signal series further comprises selecting a corrected signal sequence substantially corresponding to the sampled signal sequence.

6. (Amended) The method according to claim 1, wherein [the] sampling [in step (a)] the measured signal is executed by a measuring device at the [with high and preferably] highest accuracy provided by said measuring device.

7. (Amended) A method for correcting a measured signal[, preferably a high-speed digital pulse,] transmitted through a system having a transfer function as a function of frequency, the method comprising [the steps of]:

[(a)] sampling the measured signal to a sampled signal sequence,

[(b)] providing a signal series as a plurality of the sampled signal sequences put together successively,

[(c)] windowing the signal series with a window function,

[(d)] transforming the windowed signal series from time domain into frequency domain,

[(e)] modifying the transformed signal series with the transfer function of the system, preferably by multiplying the transformed signal series with the inverse transfer function of the system,

[(f)] re-transforming the modified transformed signal series back from the frequency domain into the time domain, and

[(g)] receiving a corrected measured signal from the re-transformed signal series.

8. (Amended) A method for providing a measured signal[, preferably a high-speed digital pulse,] for further processing, the method comprising [the steps of]:

[(a)] sampling the measured signal to a sampled signal sequence, and

[(b)] providing a signal series as a plurality of the sampled signal sequences put together successively.

9. (Amended) A software program storable on a data carrier, for executing [the] a method [of claim 1,] when operated in a computer system, said method comprising:

sampling the measured signal to a sampled signal sequence,

providing a signal series as a plurality of the sampled signal sequences put together successively,

windowing the signal series with a window function, and

recalculating a corrected measured signal from the windowed signal series using information about the frequency-dependency of the system.

10. (Amended) An apparatus for executing [one of the methods according to claims 1] a method for correcting a measured signal, said apparatus

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comprising:

a measuring device for sampling the measured signal to a sampled signal sequence,

a signal multiplication unit for providing a signal series as a plurality of the sampled signal sequences put together successively,

a device for performing windowing functions for windowing the signal series with a window function, and

a recalculation unit for recalculating a corrected measured signal from the windowed signal series using information about the frequency-dependency of the system.

11. (Amended) An apparatus for correcting a measured signal [(40), preferably a high-speed digital pulse,] transmitted through a system [(30),] comprising:

means [(50))] for sampling the measured signal [(40)] to a sampled signal sequence,

means [(200)] for providing a signal series as a plurality of the sampled signal sequences put together successively,

means [(W)] for windowing the signal series with a window function, and

means [(60)] for recalculating a corrected measured signal from the windowed signal series using information about the frequency-dependency of the system.

Please add the following new claims:

12. (Newly added) The method of claim 1, wherein said measured signal is a high speed digital pulse.

13. (Newly added) The method of claim 7, wherein said measured signal is a high speed digital pulse.

14. (Newly added) The method of claim 8, wherein said measured signal is a

high speed digital pulse.

15. (Newly added) The apparatus of claim 11, wherein said measured signal is a high speed digital pulse.

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# MINIMIZING WINDOWING EFFECTS IN PARTICULAR FOR SIGNAL RECOVERY

## BACKGROUND OF THE INVENTION

The present invention relates to correcting a measured signal transmitted through a system.

Effective and accurate measuring of high-speed pulses requires careful design of the measuring setups and methods. Increased measurement accuracy of signals with increasing frequencies together with a high degree of automatization is getting more and more difficult to achieve. While reaching ranges of above 1 GHz, signal distortion resulting from each connection, cables, switches or other elements in the transmission path is influencing the pulse performances significantly, for example with respect to pulse rise and/or fall time, ringing, droop, overshoot, or the like. Such kind of distortion is generally tried to be minimized by using (usually more expensive) high-speed cables, high-frequency connectors, switches, etc. and/or by optimizing the measurement set-up to minimize signal connection lengths. Moreover, a certain trade off between measurement accuracy and the degree of measurement automatization is often required.

Another approach for improving measuring signals can be accomplished by determining the distortion of the signal transmission path and recalculating an ideal signal (i.e. without being distorted by the signal transmission path) from the actually measured signal. The techniques for recalculating the ideal signal are well established in the theory of communications. The response of a linear system to a signal can be determined in the time domain by using the principle of convolution, and in the frequency domain by applying the principle of superposition to responses produced by the individual frequency components applied for the frequency domain representation. Multiplication in the frequency

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domain is equivalent to convolution in the time domain, and vice versa. A detailed break down of the theory, both for time domain and frequency domain analysis, can be readily taken e.g. from the introductory chapter "Signals and Channels" in "Telecommunications engineering", ISBN 0-412-38190-7, by J. Dunlop.

For the sake of simplicity and since signal recalculations are mainly applied in the frequency domain, the principle of signal recalculation shall be explained in the following mainly with respect to frequency domain analysis. It is clear, however, that signal recalculations in the time domain applying convolution techniques can be applied accordingly.

Fig. 1 illustrates the principle of signal recalculation in the frequency domain. An input signal 10 provided from a signal source 20 is transmitted through a communication channel generally represented herein as a system 30. In general, the system 30 modifies or distorts the waveform of the input signal 10 transmitted through the system 30 to an output signal 40. The amount of distortion produced by the system 30 is thereby determined by the **transfer function** (i.e. attenuation and phase shift as a function of frequency) of the system 30. The determination of the transfer function will be explained in more detail with respect to Fig. 2. The output signal 40 is measured by a measuring device 50 such as an oscilloscope.

Before recalculating the input signal 10 from the output signal 40 by a recalculation unit 60, a window function W is usually applied to the measured output signal 40 for reducing spectral leakage effects. Typical window functions are Hanning–Window, Blackman Window, or Hamming Window. The recalculation unit 60 then transforms the windowed signal from the time domain into the frequency domain usually by applying a Fast Fourier Transformation (FFT). The transformed signal is then divided by the transfer function T(f) of the system 30, and the result thereof is retransformed from the frequency domain

back into the time domain usually by applying an Inverse Fast Fourier Transformation (IFFT). The result of the retransformation represents a recalculated signal 70, which substantially corresponds to the input signal 10. The recalculated signal 70 might be applied to a signal source 80 for generating a physical signal 90 from the recalculated signal 70 or could be applied for analyzing the recalculated signal 70 with respect to its characteristics and properties.

It is clear that the recalculated signal 70 ideally equals the input signal 10 in case that:

- the transfer function T(f) applied in the recalculation unit 60 fully equals the transfer function of the system 30,
- the transformation and retransformation steps are completely inverse,
- the measuring device 50 and the recalculation unit 60 have no transfer function(s) further modulating the signals, and
- the window function W has no influence on the signals.

It is clear that any deviation from the ideal situation as outlined above will adversely affect the signal recalculation process and lead to deviations of the recalculated signal 70 from the input signal 10.

Fig. 2 illustrates the principle for determining a transfer function. A reference signal generator 100 applies a reference signal 110 to the system 30 for which the transfer function T(f) is to be determined. The reference signal 110 transmitted through the system 30 is distorted to a signal response 120 measured by a first measuring device 130. The measured signal response 120 is modulated by a window function (block W) and transformed into the frequency domain (block FFT) as a function O(f). Accordingly, the reference signal 110 is measured by a second measuring device 140, modulated by a

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window function (block W) and transformed into the frequency domain (block FFT) as a function I(f). The transfer function T(f) of the system 30 is then determined in a calculation unit 150 by dividing the frequency-transformed signal response O(f) by the frequency-transformed reference signal I(f).

It is clear that - dependent on the characteristics of the respective signals - the window functions W applied in Figs. 1 and 2 can either be the same or different window functions.

Another way for determining the transfer function T(f) would be to measure the response of the system 30 to an applied Dirac pulse.

As noted above, the frequency domain analysis executed by the recalculation unit 60 in Fig. 1 can also be undertaken in the time domain, since the time domain and the frequency domain are linked by the Fourier transform. In that case, the recalculation unit 60 would provide a convolution analysis, however, leading correspondingly to the recalculated signal 70.

When performing the recalculation as outlined for Fig. 1, several difficulties have to encountered:

- Firstly, sampling oscilloscopes are generally applied as standard measurement instruments for characterizing (digital) signals, e.g. for determining overshoot or ringing of a digital pulse. For achieving highest accuracy on signal performance measurements, it is necessary to set the time base of the oscilloscope to a value that shows only a few signal periods or even less than one signal period on the screen. This allows maximizing the sampling density of the measured signal. On the other hand, for performing the frequency transformation (such as FFT) a significant number of periods of the measured signal should be used for minimizing the effect of the signal windowing on the measurement accuracy.

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High sampling resolution and to put a huge number of signal periods into one screen shot for minimizing windowing effects, however, are contravening requirements, and a certain trade off between those requirements has to be made. However, it is apparent that any limitation of the sampling accuracy in the measuring process of Fig. 1 will correspondingly lead to a reduced accuracy of the recalculated signal 70 with respect to the input signal 10. Accordingly, any inaccuracy in the sampling process of Fig. 2 (by the measuring devices 130 and 140) will lead to a reduced accuracy of the transfer function T(f), which again reduces the accuracy of the recalculation process in the recalculation unit 60 of Fig. 1.

- Secondly, the transfer function T(f) can only be determined for discrete frequencies and a limited frequency range. That means, that if the time base of the measuring device 50 has to be changed, the transfer function should be determined again. That requires a huge effort for characterizing each measurement path for all different time bases used.
- Thirdly, even with highest accuracy for the sampling process and determination of the transfer function, the recalculated signal 70 is still slightly distorted under the influence of the windowing function.
- Fourthly, the determination of the transfer function is strongly dependent on the quality of the reference source 100 providing the reference signal 110. Any frequency limitation of the reference source 110 will automatically reduce the accuracy of the determined transfer function.

## SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide an improved correction of measured signals. The object is solved by the independent claims. Preferred embodiments are shown by the dependent claims.

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According to the invention, the signal correction process can be significantly improved in that - before modulating the corrected measured signal with a window function and recalculating the corrected measured signal - the measured signal is sampled, and the sample sequence is reproduced (preferably copied) to a series of several successive sequences. This signal series of a plurality of the sampled signal sequences is then applied for the windowing process. This allows that the measured signal can be sampled with highest accuracy, while windowing effects can be encountered by choosing a sufficiently high number of the sampled signal sequences put together to the signal series.

Since the invention does not depend on the specific method applied for recalculating corrected measured signals, frequency domain analysis as well as time domain analysis can be applied, as described in the introductory part of the description. Preferably, the recalculation process is performed using a frequency domain transformation of the windowed signal series, and by multiplying the transformed signal series with the inverse transfer function of the system. The result is retransformed into the time domain, and the corrected measured signal can be extracted therefrom preferably by selecting one sequence corresponding to the sequence of the measured signal.

In a preferred embodiment, the corrected signal sequence is selected substantially from a middle range of the signal series resulting from the recalculation process of the windowed signal series.

In another preferred embodiment, a demodulation process inverse to the modulation of the signal series with the window function is applied to the results of the recalculation process of the windowed signal series. This allows further reducing distortion effects resulting from the windowing process.

It is to be understood that the inventive signal sampling and accumulation is not limited to signal recalculations but can be applied in order to reduce windowing

effects in any kind of application.

It is clear that the invention can be partly or entirely embodied by one or more suitable software programs, which can be stored on or otherwise provided by any kind of data carrier, and which might be executed in or by any suitable data processing unit.

## BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and many of the attendant advantages of the present invention will be readily appreciated and become better understood by reference to the following detailed description when considering in connection with the accompanied drawings. Features that are substantially or functionally equal or similar will be referred to with the same reference sign(s).

Fig. 1 illustrates the principle of signal recalculation in the frequency domain,

Fig. 2 illustrates the principle for determining a transfer function, and

Fig. 3 shows a preferred embodiment of the invention.

## DETAILED DESCRIPTION OF THE INVENTION

Fig. 3 shows a preferred embodiment of the invention, whereby the lower part depicts the signal recovery process for correcting a measured signal, and the upper part illustrates the calibration process for determining the transfer function for the signal recovery process. Fig. 3 substantially corresponds to the measuring principles as depicted for Figs. 1 and 2.

The measuring device 50 in Fig. 3, as explained for Fig. 1, measures and samples the output signal 40 of the system 30. However, in contrast with the explanation as given for Fig. 1, the output signal 40 can be sampled with highest accuracy as provided by the measuring device 50. This allows that

sampling distortion can be minimized to a high degree. In case of a periodic output signal, e.g. one period can be sampled with maximum sample density for achieving highest accuracy.

The sampled output signal 40 is then applied to a signal multiplication unit 200, which captures the sampled output signal 40 and appends it thereto (n-1)-times. This results in an n-periodic signal, whereby each period represents the sampled output signal 40. In the example of Fig. 3, the sampled output signal 40 is added (or copied) nineteen times to the "original" sampled output signal 40, thus resulting in a 20-periods signal

The n-period signal provided from the multiplication unit 200 is then modulated with a window function W and supplied to the recalculation unit 60. The recalculation unit 60, as explained for Fig. 1, provides a Fourier transform (block FFT) of the windowed n-period signal, divides (block *Xfer) the frequency transformed signal by the transfer function T(f) of the system 30, and finally retransforms (block IFFT) the result back into the time domain.

The recalculated n-periodic signal provided from the recalculation unit 60 now contains n-times the recalculated signal 70, which again can be received e.g. by selecting one period.

In a preferred embodiment, the recalculated n-period signal provided from the recalculation unit 60 will be demodulated from the windowing function W in a demodulation unit 210. The demodulation unit 210 preferably divides the n-period signal from the recalculation unit 60 by the windowing function W (as applied in the previous windowing process).

In another embodiment, the n-periodic signal from the recalculation unit 60 is applied either directly or via the demodulation unit 210 to a period selection unit 220. The period selection unit 220 selects one period of the n-periodic signal, preferably in a middle range of the n-periodic signal. In the example of Fig. 3,

the period selection unit 220 will select the eleventh period of the 20-period signal.

The upper part of Fig. 3 illustrates the calibration process preferably applied for determining the transfer function T(f) of the system 30. It is clear, however, that the transfer function T(f) can also be determined by other processes as known in the art, and that the invention is not limited to the specific embodiment as depicted in the upper part of Fig. 3. In accordance with the above said for Fig. 2, the first measuring device 130 measures and samples the signal response 120 of the system 30, while the second measuring device 140 measures and samples the reference signal 110 applied to the system 30. Also in accordance with the above said, a multiplication unit 200A provides an n-period signal from the sampled signal response 120, and a multiplication unit 200B provides an n-period signal from the sampled reference signal 110. The signal response 120 as well as the reference signal 110 are preferably sampled with highest accuracy achievable by the measuring units 130 and 140. The n-periods signals from the multiplication units 200A and 200B are each modulated with a window function W and transformed into the frequency domain, as indicated by the respective blocks W and FFT, to a transformed signal response 210A and a transformed reference signal 210B.

The transfer function T(f) can then be determined by dividing the transformed signal response 210A by the transformed reference signal 210B. However, instead of directly dividing the transformed signal response 210A by the transformed reference signal 210B, a cross spectrum and an auto spectrum can be determined, as shown in the upper part of Fig. 3. A cross spectrum unit 225 determines the cross spectrum by complex multiplying the spectra of the transformed signal response 215A and the transformed reference signal 215B. An auto spectrum unit 230 determines the auto spectrum by complex multiplying the spectrum of the transformed reference signal 210B with itself. A transfer function determining unit 240 can then determine the transfer function

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CLAIMS:

1. A method for correcting a measured signal, preferably a high-speed digital pulse, transmitted through a system, the method comprising the steps of:

(a) sampling the measured signal to a sampled signal sequence,

(b) providing a signal series as a plurality of the sampled signal sequences put together successively,

(c) windowing the signal series with a window function, and

(d) recalculating a corrected measured signal from the windowed signal series using information about the frequency-dependency of the system.

2. The method of claim 1, wherein step (d) comprises the steps of:

(d1) transforming the windowed signal series from time domain into frequency domain,

(d2) modifying the transformed signal series with a transfer function as a function of frequency of the system, preferably by multiplying the transformed signal series with the inverse transfer function of the system,

(d3) re-transforming the modified transformed signal series back from the frequency domain into the time domain, and

(d4) receiving the corrected measured signal from the re-transformed signal series.

3. The method of claim 1 or 2, wherein step (d) further comprises a step of modifying the corrected measured signal with a function inverse to the

window function.

4. The method of claim 2 or 3, wherein the step (d4) comprises a step of selecting a corrected signal sequence substantially corresponding to the sampled signal sequence.

5. The method of claim 4, wherein the selected corrected signal sequence is selected substantially from a middle range of the re-transformed signal series.

6. The method according to claim 1, wherein the sampling in step (a) is executed with high and preferably highest accuracy.

7. A method for correcting a measured signal, preferably a high-speed digital pulse, transmitted through a system having a transfer function as a function of frequency, the method comprising the steps of:

(a) sampling the measured signal to a sampled signal sequence,

(b) providing a signal series as a plurality of the sampled signal sequences put together successively,

(c) windowing the signal series with a window function,

(d) transforming the windowed signal series from time domain into frequency domain,

(e) modifying the transformed signal series with the transfer function of the system, preferably by multiplying the transformed signal series with the inverse transfer function of the system,

(f) re-transforming the modified transformed signal series back from the frequency domain into the time domain, and

(g) receiving a corrected measured signal from the re-transformed

signal series.

8. A method for providing a measured signal, preferably a high-speed digital pulse, for further processing, the method comprising the steps of:

   (a) sampling the measured signal to a sampled signal sequence, and

   (b) providing a signal series as a plurality of the sampled signal sequences put together successively.

9. A software program storable on a data carrier, for executing the method of claim 1, when operated in a computer system.

10. An apparatus for executing one of the methods according to claims 1.

11. An apparatus for correcting a measured signal (40), preferably a high-speed digital pulse, transmitted through a system (30), comprising:

    means (50)) for sampling the measured signal (40) to a sampled signal sequence,

    means (200) for providing a signal series as a plurality of the sampled signal sequences put together successively,

    means (W) for windowing the signal series with a window function, and

    means (60) for recalculating a corrected measured signal from the windowed signal series using information about the frequency-dependency of the system.

T(f) by dividing the determined cross spectrum by the determined auto spectrum. This allows eliminating white noise effects thus increasing accuracy.

The determined transfer function T(f) is then preferably stored in a storage 250 and can be requested from the recalculation unit 60.

In a preferred embodiment, an interpolation unit 260 provides an interpolation of the transfer function T(f) from discrete frequency values to a continued frequency spectrum. This is preferably accomplished by a linear interpolation between two discrete frequency points or a spline interpolation.

**Atttorney Docket: 20-99-0025**

## ABSTRACT

Disclosed is the correcting of a measured signal (40), such as a high-speed digital pulse, transmitted through a system (30). The measured signal (40) is sampled to a sampled signal sequence, and a signal series is provided as a plurality of the sampled signal sequences put together successively. The signal series is windowed with a window function, and a corrected measured signal is recalculated from the windowed signal series using information about the frequency-dependency of the system.

[Fig. 3]

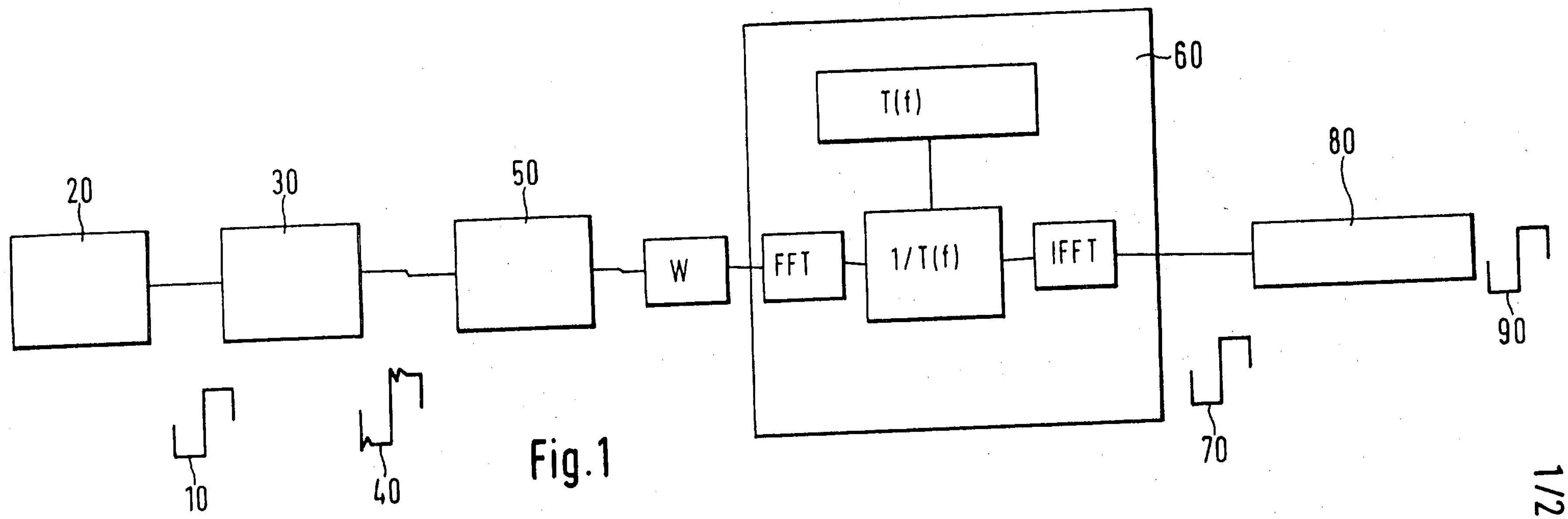
20
30
50
W
FFT
T(f)
1/T(f)
IFFT
60
80
90
70
10
40

Fig.1

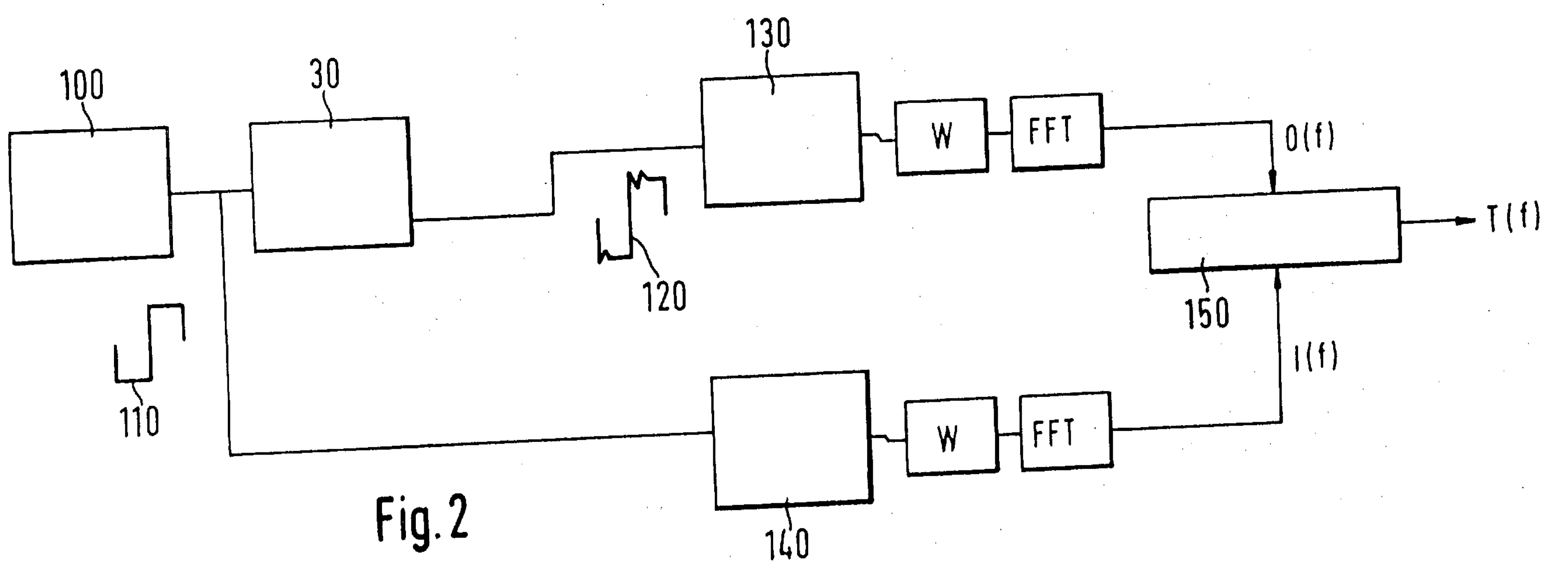
100
30
130
W
FFT
0(f)
T(f)
150
I(f)
W
FFT
140
110
120

Fig.2

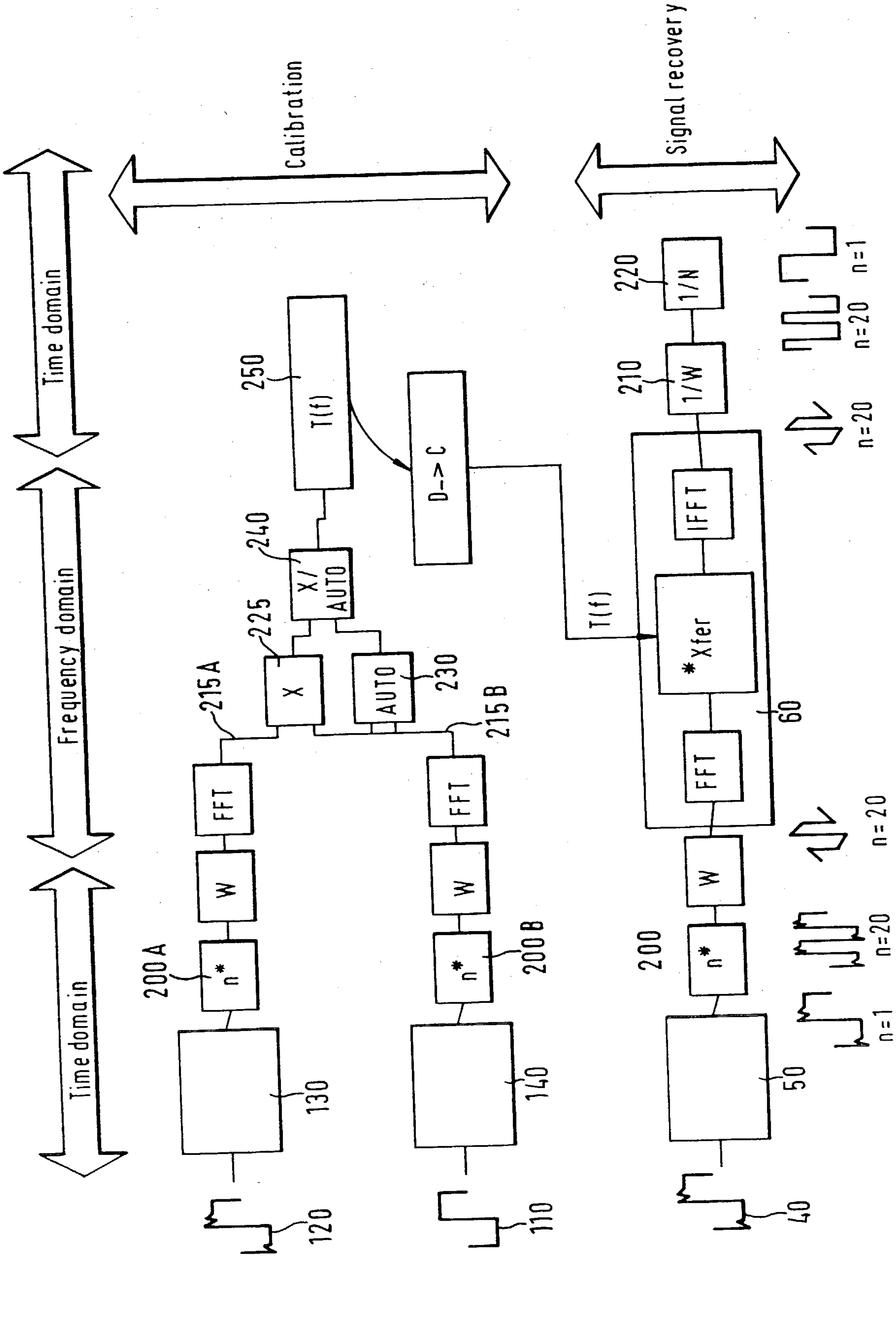
Time domain
Frequency domain
Time domain
Calibration
Signal recovery
120
130
200 A
W
FFT
215 A
225
X
240
X/
AUTO
250
T(f)
D–> C
230
AUTO
215 B
110
140
200 B
40
50
200
n=1
n=20
60
*Xfer
IFFT
T(f)
210
1/W
220
1/N

Fig.3

# DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

Docket No. **20 99 0025**

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor of the subject matter that is claimed and for which a patent is sought on the invention entitled:

**MINIMIZING WINDOWING EFFECTS IN PARTICULAR FOR SIGNAL RECOVERY**

the specification of which

(check one) ____ is attached hereto.

**XX** was filed on **January 16, 2002** as Application Serial No. **10/069,084** and was amended on ______________ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to the examination of this application as defined in Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate(s) listed below and have also identified below any foreign application(s) for patent or inventor's certificate(s) having a filing date before that of the application on which priority is claimed:

| Prior Foreign Application(s) | | | Priority Claimed |
|---|---|---|---|
| **PCT/EP99/10349** (Number) | **PCT** (Country) | **December 23, 1999** (Day/Mon/Year Filed) | X Yes ___ No |
| (Number) | (Country) | (Day/Mon/Year Filed) | ___ Yes ___ No |
| (Number) | (Country) | (Day/Mon/Year Filed) | ___ Yes ___ No |

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

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| | | |
|---|---|---|
| (Application Serial No.) | (Filing Date) | (Status - patent, pend., abandon.) |
| (Application Serial No.) | (Filing Date) | (Status - patent, pend., abandon.) |
| (Application Serial No.) | (Filing Date) | (Status - patent, pend., abandon.) |

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

1-00

| FULL NAME OF INVENTOR | LAST NAME<br>**Steiner** | FIRST NAME<br>**Rolf** | MIDDLE NAME |
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Inventor's signature *Rolf Steiner* Date *26. Feb.*, 2002
**Rolf Steiner**